An Assessment of Witch Flounder (*Glyptocephalus cynoglossus*) Stock Structure

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Objective

The objective of this Working Paper is to summarize the existing literature regarding the stock structure of witch flounder (*Cynoglossus glyptocephalus*) in U.S. and Canadian waters. To meet this objective I undertook an interdisciplinary literature review that considered past research on the distribution, life history, spawning behavior, and genetics of this species. This Working Paper addresses Term of Reference 8 to the 62nd Stock Assessment Workshop for witch flounder: "*Evaluate the validity of the current stock definition, taking into account what is known about the migration, and make a recommendation about whether there is a need to modify the current stock definition for future stock assessments*."

Distribution

Witch flounder are distributed on both sides of the Atlantic Ocean, and in the northwest Atlantic they range from Virginia to Labrador (Wigley and Burnett, 2003), although the species is not commercially abundant south of Cape Cod (Burnett et al., 1992). In the absence of any directed stock identification research, witch flounder is assessed and managed as a unit stock from the Gulf of Maine southward to the coast of Virginia (Burnett and Clark, 1983; Figure 1), which covers an area of 141,966km^2 (Wigley and Emery, 2012).

In the mid-Atlantic and southern New England witch flounder exhibit a patchy distribution along the continental shelf and slope (Figure 2). Witch flounder are continuously distributed on the northern edge of Georges Bank, in the Gulf of Maine, and in the Bay of Fundy. Witch flounder are also common across the Scotian Shelf, in the Gulf of St. Lawrence, on the Grand Banks and Flemish Cap, and off the southern coast of Labrador (Figure 2). Data collected on the Northeast Fisheries Science Center biannual trawl survey from 1982 to 1989 also offers insight into the distribution of witch flounder (Figure 3). General patterns of distribution were similar between the spring and fall surveys, and witch flounder were continuously distributed throughout the Gulf of Maine, in the mouth of the Bay of Fundy, and on the western Scotian Shelf (Figures 3A and 3B). Concentrations of witch flounder were also present on the northern and southern flanks of Georges Bank and in the Great South Channel, but witch flounder were largely absent from shallow water habitats on top of Georges Bank. Witch flounder exhibited a patchy distribution on the continental slope and shelf in the waters of southern New England and the Mid-Atlantic Bight.

Witch flounder has been described as a deepwater fish that are seldom caught in water shallower than 15 fathoms (Bigelow and Schroeder, 1953). This species is associated with muddy and sandy habitats, and are common in the Gulf of Maine at depths ranging from 100 to 275m (Wigley and Burnett, 2003). Bigelow and Schroeder (1953) described the best catches of witch flounder occurring between 60 and 150 fathoms (110-275m), and noted that witch flounder are also abundant on smooth grounds between rock patches. Based on trawl survey data, Burnett et al. (1992) determined that the annual mean depth occupied by adult witch flounder was 147m, while the seasonal average depth occupied by juvenile witch flounder ranged from 112m in the winter to 198m in the summer. Based on 10 years (1970-1979) of summer trawl survey data, Scott (1982) described the distribution of witch flounder on the Scotian Shelf. Scott (1982) reported that witch flounder were captured at a wide range of depths (15-200+ m) and temperatures (0-13^{o}C), and concluded that the preferred depth and temperature range was 80-89m and 5-7^{o}C. Scott (1982) also noted significant concentrations of witch flounder in the Bay of Fundy, and in the Laurentian Channel. Off Nova Scotia and in the Gulf of St. Lawrence, Powles and Kohler (1970) captured adult witch flounder in depths ranging from 36-270m in summer and 90 -432m in the winter. Powles and Kohler (1970) also reported that juvenile witch flounder occupy deeper habitats than adults, and concluded that the disparate distribution of the juveniles and adults would minimize competition for food and resources (i.e., niche partitioning). However, Walsh (1987) cautioned that the niche partitioning hypothesis proposed by Powles and Kohler (1970) may have been biased by differences in the efficiency of the survey gear used in the different regions.

Witch flounder is somewhat unique amongst the flatfish in New England in that it can inhabit deep waters along the continental slope. Bigelow and Schroeder (1953) reported witch flounder being taken in a number of deep water locations including off of Martha's Vineyard (1340m), Nova Scotia (1569m), and North Carolina (1100m). Markle and Musick (1974) captured juvenile witch flounder along the continental slope of the mid-Atlantic Bight at a depth of approximately 900m, and described them as a dominant species in the slope finfish community. Markle (1975) reported that juvenile witch flounder were present in every tow conducted between 256 and 1080m (44 stations) off the continental slope of Virginia. Although the majority of the witch flounder sampled by Markle (1975) were juveniles, animals up to 48cm were caught, suggesting that adult witch flounder also occupy these deep water habitats. Wigley and Burnett (2003) reported that witch flounder were caught in approximately half of the stations that were trawled in slope waters of southern New England at depths between 273 and 1371m, and reported that some animals were in spawning condition at the time of capture.

Life History Characteristics

Witch flounder spawn near the bottom, releasing buoyant, pelagic eggs that have an incubation period of 7-8 days at temperatures ranging from 7.8 to 9.4^{o}C (Bigelow and Schroeder, 1953; Cargnelli et al., 1999). These eggs are predominantly sampled over relatively shallow habitats on the continental shelf, but eggs have also been observed over the continental slope in water up to 1250m (Cargnelli et al., 1999). Witch flounder larvae are pelagic and remain in the water column for an extend period of time, 4 to 12 months, before undergoing metamorphosis and settling to the bottom (Bigelow and Schroeder, 1953; Evseenko and Nevinsky, 1975; Neilson and Hurley, 1986; Cargnelli et al., 1999). The pelagic nature of the eggs and larvae, along with the extended pelagic larval duration, means that the potential for dispersal during the early life history stages must be quite high. For example, Markle (1975) hypothesized that larvae may be advected from spawning grounds in the Gulf of Maine to nursery areas along the continental shelf south of Georges Bank. Wigley and Burnett (2003) surmised that eggs and larvae spawned off Labrador and the Grand Bank could be advected to the continental slope of the Mid-Atlantic Bight, via transport in the Labrador Current.

The life history of witch flounder has been well studied, both in U.S. and Canadian waters. When compared to other flatfish in the region, witch flounder are relatively long-lived. In US waters, witch flounder may live to be 24 years old (Burnett et al., 1992). Powles and Kennedy (1967) reported that witch flounder off the eastern Scotian Shelf (area 4W) may reach a maximum age of 20 years.

Like many flatfish, witch flounder exhibit sexually dimorphic growth, with females attaining larger maximum sizes than males (Bowering, 1976), and maturing at later ages than males (Table 1). Wigley and Burnett (2003) compared the growth rates of witch flounder from the Gulf of Maine, the mid-Atlantic Bight, and the deep-water of the continental slope (Figure 4). They observed that growth rates were similar between witch flounder from the Gulf of Maine and the mid-Atlantic Bight, while witch flounder in deep water habitats exhibited significantly slower growth. Wigley and Burnett (2003), also noted that the length-weight relationship was similar for witch flounder in the Gulf of Maine and mid-Atlantic Bight, but significantly different for witch flounder captured in deep waters, which tended to be lighter at a given length than those fish captured on the shelf.

There maturity schedules of witch flounder in U.S. and Canadian waters have been well studied (Table 1). In general, witch flounder exhibit a latitudinal gradient in A_{50}, with individuals in southerly habitats maturing at younger ages than those further to the north and east. Beacham (1983) hypothesized that the maturity schedule of witch flounder was driven by water temperature, with fish in warmer habitats maturing at younger ages than those in colder habitats.

Witch flounder sampled on the deep waters of the continental slope exhibited a later age at maturity than individuals sampled from the Gulf of Maine (Table 1; Burnett et al., 2003). The age at maturity was similar for male witch flounder sampled in the Gulf of Maine from 1977-1981 (A_{50} = 1977-1981) to those sampled on the western Scotian Shelf from 1975-1979 (A_{50} = 5.1) (Beacham, 1983; Burnett et al., 1992). However, over the same time period female witch flounder from the Gulf of Maine matured earlier (A_{50} = 6; Burnett et al., 1992), than those on the Scotian Shelf (A_{50} = 7.2; Beacham et al., 1983).

In many regions, declines in A_{50} have been observed over time. Beacham (1983) suggested that the decline in age at maturity may be related to fishery induced evolution, with the late maturing genotype gradually being selected out of the population by harvesting. Burnett et al (2003) also suggested that changes in maturity schedules could also be attributed to year-class strength. If fisheries induced evolution has occurred for witch flounder, it could have important implications for the dynamics and productivity of this resource. Changes in the age and size at maturity could also confound attempts to compare the maturity schedules between different regions, if the samples were not collected at similar times.

Spawning Activity

Distribution of Adult Spawners **-**The available data suggests that the spawning activity of witch flounder is widespread, both in space and time. Bigelow and Schroeder (1953) report that witch flounder in the Gulf of Maine spawn in late spring and summer, and surmised that the peak spawning likely occurs in July and August. They sampled witch flounder eggs and early stage larvae at temperatures ranging from 3.9^{o}C in the early spring to 12.7^{o}C in the summer, and concluded that spawning occurs across a range of temperatures. Burnett et al. (1992) used survey data to map the distribution of spawning witch flounder (maturity stages defined as ripe and ripe and running) in the Gulf of Maine and Georges Bank (Figure 5). They reported that ripe fish were captured between April and November, and that spawning occurred in depths ranging from 24 to 360m, and at temperatures between 2.9 and 8.9^{o}C. Spawning witch flounder were captured throughout the Gulf of Maine, with the highest concentrations of spawning fish occurring in the western and northern portions of the Gulf of Maine, at depths of approximately 130m and temperatures between 4.6 and 5.1^{o}C. Burnett et al., (1992) also noted the presence of spawning witch flounder on the western Scotian Shelf, and at the mouth of the Bay of Fundy, along the Hague Line.

Witch flounder were also collected in spawning condition during deep-water surveys along the continental slope of the Mid-Atlantic Bight, suggesting that spawning is not restricted to habitats along the continental shelf (Wigley and Burnett, 2003). The presence of witch flounder eggs and larvae in this region (Smith et al., 1975; Berrien and Sibunka, 1999) is further indication that witch flounder spawn in deep waters habitats along the continental slope.

Neilson and Hurley (1986) examined the distribution of spawning witch flounder (maturity stages defined as ripe, ripe and running, or spent) on the western Scotian Shelf during spring and summer trawl survey conducted by the Canadian Department of Fisheries and Oceans. During the spring, spawning witch flounder were commonly observed at the mouth of the Bay of Fundy and off southwestern Nova Scotia in depths greater than 100m (Figure 6A). In the summer, fewer spawning witch flounder were caught, and their concentration was primarily located in the mouth of the Bay of Fundy (Figure 6B). On the eastern Scotian Shelf, witch flounder spawning has been reported in the late spring and summer (Leim and Scott, 1966). Given the protracted spawning behavior exhibited by this species, Powles and Kohler (1970) hypothesized that spawning may occur over a wide range of depths and habitats, depending upon the time of year.

Distribution of Eggs and Larvae - During a coast-wide ichthyoplankton sampling program, Berrien and Sibunka (1999) observed a latitudinal gradient in spawning time. Across the entire U.S. stock, peak egg production was observed in June. Eggs were sampled in February and March near Chesapeake Bay, spawning extended into southern New England by April, and into the Gulf of Maine and Georges Bank by May. In June, witch flounder eggs were rarely sampled in southern New England, but were widespread across the southern flank of Georges Bank and in the Gulf of Maine with notable concentrations in Massachusetts Bay. From July to August witch flounder eggs were widespread throughout the inshore Gulf of Maine and the Great South Channel. September appeared to be the end of the spawning season, as few eggs were sampled in October. Evseenko and Nevinsky (1975) sampled witch flounder eggs and larvae on Georges Bank in May and June, and surmised that spawning activity was likely occurring there.

Smith et al (1975) reported on the monthly concentration and length frequency of witch flounder larvae sampled between North Carolina and Cape Cod. Similar to Berrien and Sibunka (1999), they observed a latitudinal gradient in the time of spawning. Larvae were sampled in April between Virginia and New Jersey. By May, larvae were sampled throughout the Mid-Atlantic Bight, and into southern New England, and by June the highest concentrations of larvae were observed in southern New England. Little spawning activity was observed south of Cape Cod in August.

The distribution of witch flounder eggs has also been examined in Canadian waters. Neilson and Hurley (1986) reported on concentrations of witch flounder eggs on the western Scotian Shelf from a survey conducted in June of 1983. Witch flounder eggs were present on the western Scotian Shelf, particularly on German Bank and off St. Mary’s Bay, but witch flounder eggs were only collected in one location on Georges Bank (Figure 7). Neilson et al (1988) reported on the spatial and temporal distribution of witch flounder eggs observed across the Scotian Shelf from 1979-1982. In area 4X, witch flounder eggs were sampled from May to

August, with the peak concentration observed in June. In Area 4W eggs were sampled from May to September, with a peak in June, and in area 4W eggs were sampled from July to September. Based on the distribution of eggs and spawning adults, Neilson et al (1988) could not reach any definitive conclusions about the stock structure of witch flounder on the Scotian Shelf. Brander and Hurley (1992) reported on the timing and location of witch flounder eggs collected as part of the Scotian Shelf Ichthyoplankton Survey, which was conducted from 1979-1981. Brander and Hurley reported that witch flounder eggs were collected on the western Scotian Shelf from March until October, with the highest concentrations of early stage eggs observed in June (Figure 8). Similar to Neilson et al. (1988), they observed that spanwing appears to occur earlier on the western Scotian Shelf (area 4X) and that spawning occurred progressively later as they sampled to the north and east (areas and 4V and 4W).

Movement Patterns

Absent any directed tagging studies, the seasonal movements of witch flounder in U.S. waters are not well understood. Instead, seasonal movement patterns have often been inferred from distributions observed during trawl surveys. Although witch flounder have typically been considered to a relatively stationary species (e.g., Bigelow and Schroeder, 1953; Cargnelli et al., 1999), local fishermen report that witch flounder are the most migratory of all flatfish in the Gulf of Maine (David Goethel and Frank Mirarchi, personal communication). Burnett and Clark (1983) concluded that witch flounder do not exhibit any clearly defined seasonal movements, but noted that witch flounder may form dense pre-spawning aggregations in the spring. These pre-spawning aggregations were also described in Canadian waters by Powles and Kohler (1970), and fishermen often report high Catch Per Unit Effort in the western Gulf of Maine in the spring, which may be indicative of a pre-spawning aggregation. On the Scotian Shelf, Powles and Kohler (1970) surmised that witch flounder make short distance (5-10 mile) migrations between summer and winter habitats, and observed that witch flounder near Cape Breton may undertake seasonal migrations that are more extensive than those observed on the Scotian Shelf.

Meristic Characters

There have not been any directed studies using meristic characters (e.g., fin ray counts) to examine the stock structure of witch flounder in U.S. waters. However, Bowering and Misra (1982) collected witch flounder throughout Newfoundland and Labrador and enumerated their dorsal fins, anal fins, caudal fins, pectoral fins and vertebrae. Pairwise comparisons of meristic characters from the sample locations that were based upon the multivariate technique they developed indicated significant differences amongst locations. The results suggested that witch flounder in the Newfoundland and Labrador regions exhibit discrete population structure at a spatial scale that was smaller than the boundaries used to manage the stocks. Thus, meristic characters appear to offer potential as an approach to investigate witch flounder stock structure in U.S. waters.

Genetic Analysis

There have not been any directed studies using genetic markers to investigate the stock structure of witch flounder in U.S. waters. However, Fairbairn (1981) examined genetic variability at two protein loci (phosphoglucomutase and superoxide dismutase) for witch flounder collected in Newfoundland and Labrador. Her analysis revealed that witch flounder may exhibit local population structure in the water of Newfoundland and Labrador, and that multiple independent stocks may exist within management units. Her conclusions were in close agreement with the meristic study completed by Bowering and Misra (1982) in the same region.

Unresolved Questions

Connectivity between areas 5Y, 5Z, and 4X - Based on the available literature, it is currently unclear whether witch flounder on the western Scotian Shelf (4X) and those in U.S. waters (Area 5Z and 5Y) comprise a separate stock, or whether it would be more appropriate to combine these two groups for management and assessment purposes. Trawl survey data demonstrates that witch flounder exhibit a continuous distribution from the eastern Gulf of Maine, into the Bay of Fundy, and on to the western Scotian Shelf (Figures 2 and 3). In addition, there are no clear breaks in the distribution of spawning witch flounder between the Gulf of Maine and the western Scotian Shelf (Figure 5). After considering this information, Neilson and Hurley (1986) concluded that there was little evidence to suggest that witch flounder in the Gulf of Maine (Area 5Y) and the western Scotian Shelf (area 4X) comprise separate stocks. There is overlap in the spawning season of witch flounder in the Gulf of Maine and those on the Scotian Shelf. In addition, the maturity schedules of witch flounder are similar between the two regions (Table 1), although direct comparisons of A_{50} and L_{50} are likely to be confounded by the trends in maturation that have been observed throughout the northwest Atlantic. Given the long pelagic larval duration exhibited by this species, and the prevailing currents in the region, larval transport from the Scotian Shelf to the Gulf of Maine and Georges Bank could occur, with important implications for the recruitment and stock dynamics of witch flounder in U.S. waters. The distribution of witch flounder eggs on the Scotian Shelf has been mapped by both Neilson and Hurley (1986; Figure 7), and Brander and Hurley (1992; Figure 8), and demonstrate that during certain months witch flounder eggs can be continuously distributed from the western Scotian Shelf to the Hague Line. These ichthyoplankton data imply that there is likely egg and larval exchange between Canadian and U.S. stocks of witch flounder.

Stock Identity of Deep-Water Witch Flounder **–** Wigley and Burnett (2003) showed that the life history traits (e.g., age at maturation, length-weight relationship), and otolith morphometry of witch flounder sampled in deep waters off the continental shelf were significantly different from those collected on the shelf of the mid-Atlantic Bight and the Gulf of Maine. Wigley and Burnett (2003) also noted that the productivity (e.g., YPR and SPR) of witch flounder in deep water differed significantly from the population on the shelf. Based on these findings, Wigley and Burnett (2003) concluded that witch flounder on the continental slope of southern New England and the mid-Atlantic Bight are likely a separate group from the population in the Gulf of Maine and Georges Bank. However, the connectivity between the deep-water witch flounder and populations elsewhere is uncertain. For example, further research is needed to determine whether the deep-water populations are self-sustaining, or if they receive a subsidy of larvae from an upstream spawning location. In addition, it is unknown whether eggs and larvae spawned in deep-water habitats can contribute to recruitment on the continental shelf. If there is connectivity between these two disparate habitats, it would imply that there is a cryptic biomass of spawning adults present on the continental slope which would be unavailable to the surveys that are included in the stock assessment for this species. This cryptic biomass of spawners could confound efforts to interpret relationships between stock and recruitment.

Conclusions

The stock structure of witch flounder is highly uncertain (Burnett and Clark, 1983; Cargnelli et al., 1999) and multidisciplinary stock identification studies are needed to address unresolved questions. As the fishery for this species developed, witch flounder was the subject of a number of directed research studies in the 1970's and 1980's. However, in recent years, comparatively little research has been done to examine the biology and stock structure of witch flounder. Given the tremendous advances in stock identification techniques that have occurred in the intervening time period (Cadrin et al., 2014), new research efforts should be able to address many of the unresolved questions for this species. Directed stock identification studies in Newfoundland and Labrador based on meristic characters (Bowering and Misra, 1982) and early genetic techniques (Fairbairn, 1981) revealed that witch flounder may exhibit local population structure, at spatial scales much smaller than the units that were being used to manage the stocks. Although witch flounder may exhibit local population structure in U.S. waters (Cargnelli et al., 1999), the available data lacks the resolution needed to definitely address this possibility. Individual-based models could provide insight into the transport of witch flounder eggs and larvae, and may help identify connectivity between populations on the continental shelf and those in deep water.

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Tables

Area Studied	Sample Collection Dates	Sex	A50	L50	Source
Gulf of Maine and Georges Bank	1977-1981	Male	5	29.6	Burnett et al., 1992
Gulf of Maine and Georges Bank	1982-1984	Male	4	24.3	Burnett et al., 1992
Gulf of Maine and Georges Bank	1977-1984	Female	6	33.5	Burnett et al., 1992
Gulf of Maine	1994-1999	Male	3.5	27.3	Wigley and Burnett, 2003
Gulf of Maine	1994-1999	Female	5.1	34.2	Wigley and Burnett, 2003
US Continental Slope (>366m)	1994-2001	Male	6.4	30.2	Wigley and Burnett, 2003
US Continental Slope (>366m)	1994-2001	Female	8.8	36.4	Wigley and Burnett, 2003
Scotian Shelf	1965	Male	7	37	Powles and Kohler, 1970
Scotian Shelf	1965	Female	10	44	Powles and Kohler, 1970
Northeast Newfoundland Shelf	1958-1974	Male	4.2	30	Bowering, 1976
Northeast Newfoundland Shelf	1958-1974	Female	8.6	50	Bowering, 1976
Gulf of St. Lawrence	1958-1974	Male	6.2	25	Bowering, 1976
Gulf of St. Lawrence	1958-1974	Female	9.9	40	Bowering, 1976
Grand Bank	1958-1974	Male	5.6	29	Bowering, 1976
Grand Bank	1958-1974	Female	8.4	44	Bowering, 1976
St. Pierre Bank	1958-1974	Male	5.1	28	Bowering, 1976
St. Pierre Bank	1958-1974	Female	10.2	44	Bowering, 1976
Western Scotian Shelf (Area 4X)	1959-1964	Male	7.7	34	Beacham, 1983
Western Scotian Shelf (Area 4X)	1975-1979	Male	5.1	30	Beacham, 1983
Western Scotian Shelf (Area 4X)	1959-1964	Female	10.2	44	Beacham, 1983
Western Scotian Shelf (Area 4X)	1975-1979	Female	7.2	34	Beacham, 1983
Emerald Bank (Area 4W)	1959-1964	Male	7.7	36	Beacham, 1983
Emerald Bank (Area 4W)	1975-1979	Male	5.8	29	Beacham, 1983
Emerald Bank (Area 4W)	1959-1964	Female	9.2	42	Beacham, 1983
Emerald Bank (Area 4W)	1975-1979	Female	7.1	33	Beacham, 1983
Banquereau (Area 4Vs)	1959-1964	Male	6.9	36	Beacham, 1983
Banquereau (Area 4Vs)	1975-1979	Male	6.1	31	Beacham, 1983
Banquereau (Area 4Vs)	1959-1964	Female	9.2	43	Beacham, 1983
Banquereau (Area 4Vs)	1975-1979	Female	7.6	34	Beacham, 1983
Cape Breton (Area 4Vn)	1959-1964	Male	7.8	37	Beacham, 1983
Cape Breton (Area 4Vn)	1975-1979	Male	9.2	33	Beacham, 1983
Cape Breton (Area 4Vn)	1959-1964	Female	10.5	44	Beacham, 1983
Cape Breton (Area 4Vn)	1975-1979	Female	8.8	33	Beacham, 1983
Gulf of St. Lawrence	1959-1964 & 1975-1979	Male	8	33-34	Beacham, 1983
Gulf of St. Lawrence	1959-1964	Female	12.6	42	Beacham, 1983
Gulf of St. Lawrence	1975-1979	Female	8.8	35	Beacham, 1983

Table 1. Published maturity schedules for witch flounder in the northwest Atlantic.

Figures

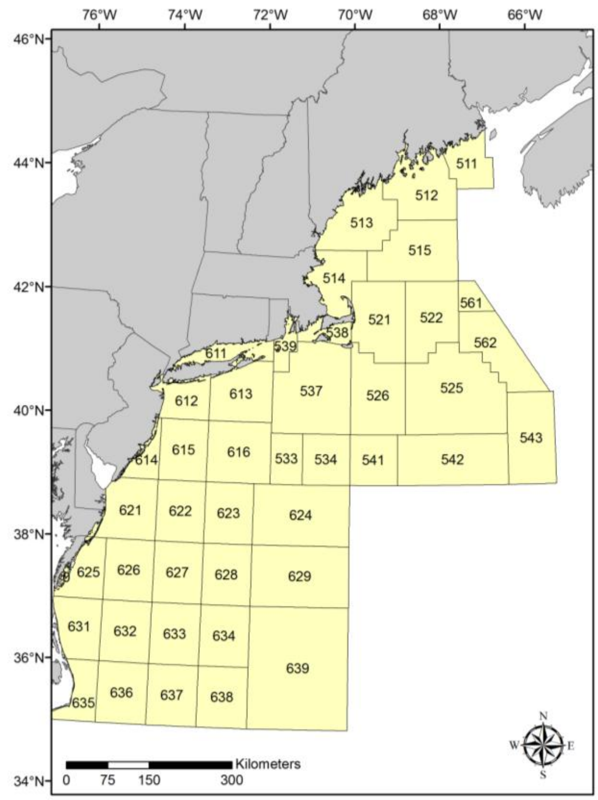

Figure 1. Statistical areas used to define the unit stock boundaries for witch flounder in U.S. waters.

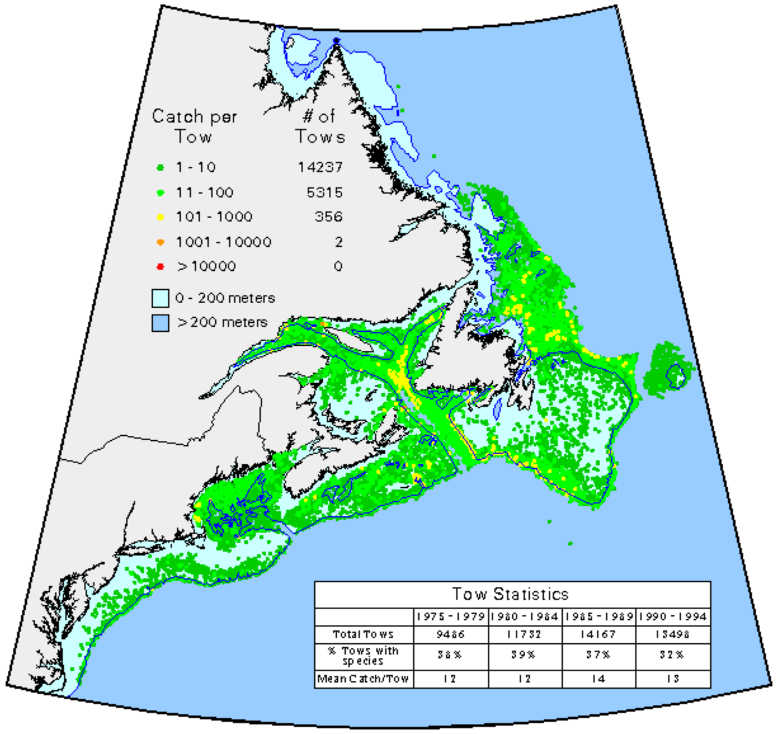

Figure 2. Distribution of witch flounder in U.S. and Canadian waters observed in trawl surveys from 1975-1994. Figure taken from Brown and O'Boyle, 1996.

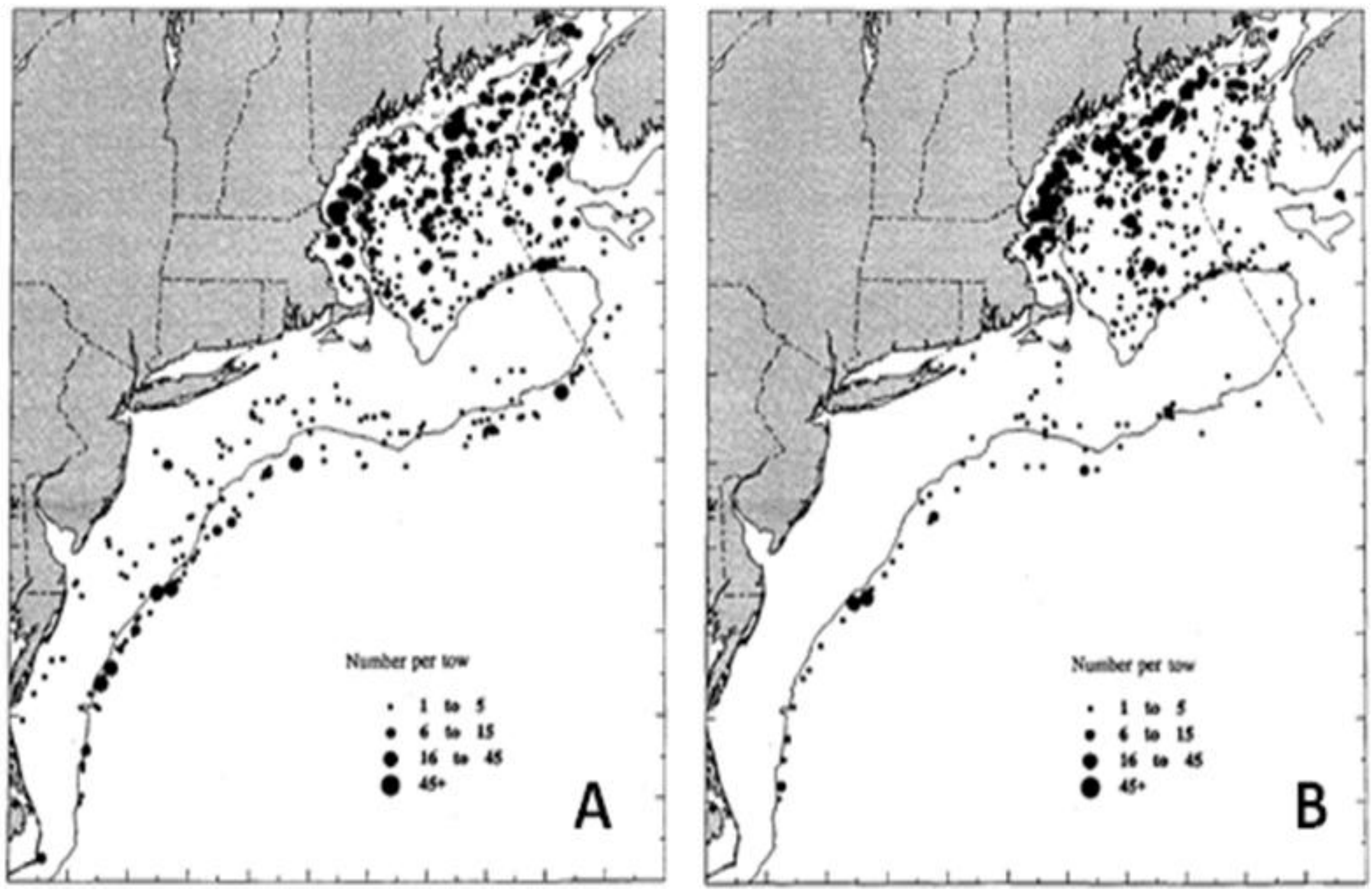

Figure 3. Distribution of witch flounder in U.S. and Canadian waters observed during the Northeast Fisheries Science Center spring (Figure 3A) and fall (Figure 3B) bottom trawl surveys from 1982-1989. Figures taken from Wigley and Mayo (1996).

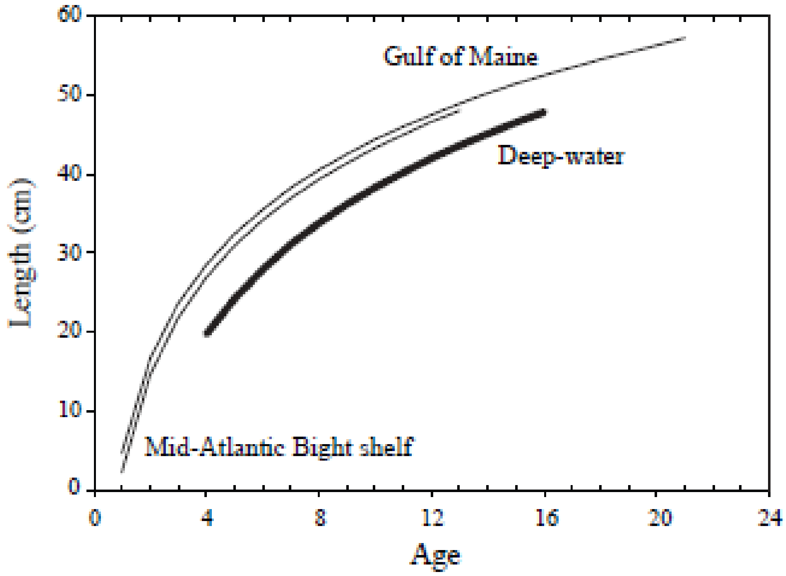

Figure 4. Growth curves for witch flounder sampled in the Gulf of Maine, mid-Atlantic Bight, and the deep water of the continental slope. Figure taken from Wigley and Burnett (2003).

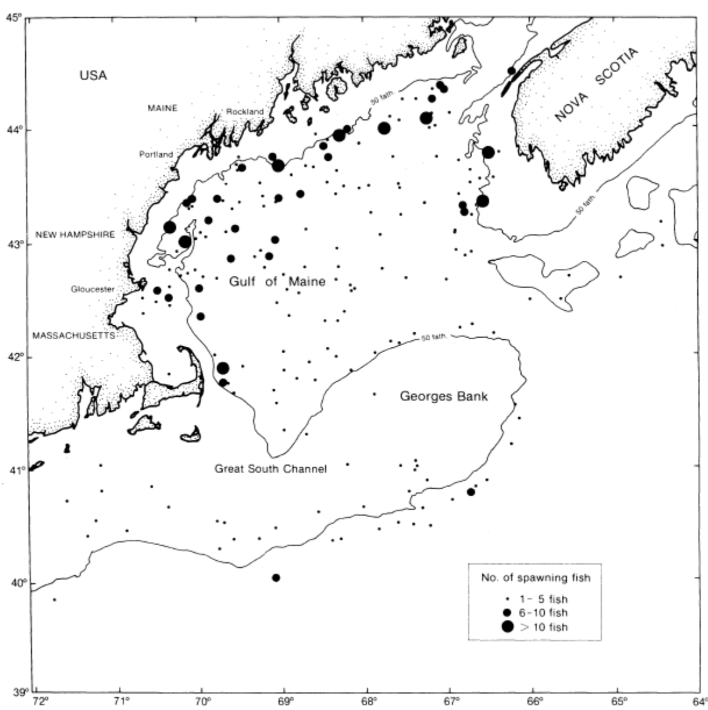

Figure 5. Distribution of spawning witch flounder observed in NEFSC bottom trawl surveys from 1977 to 1984. Figure taken from Burnett et al. 1992.

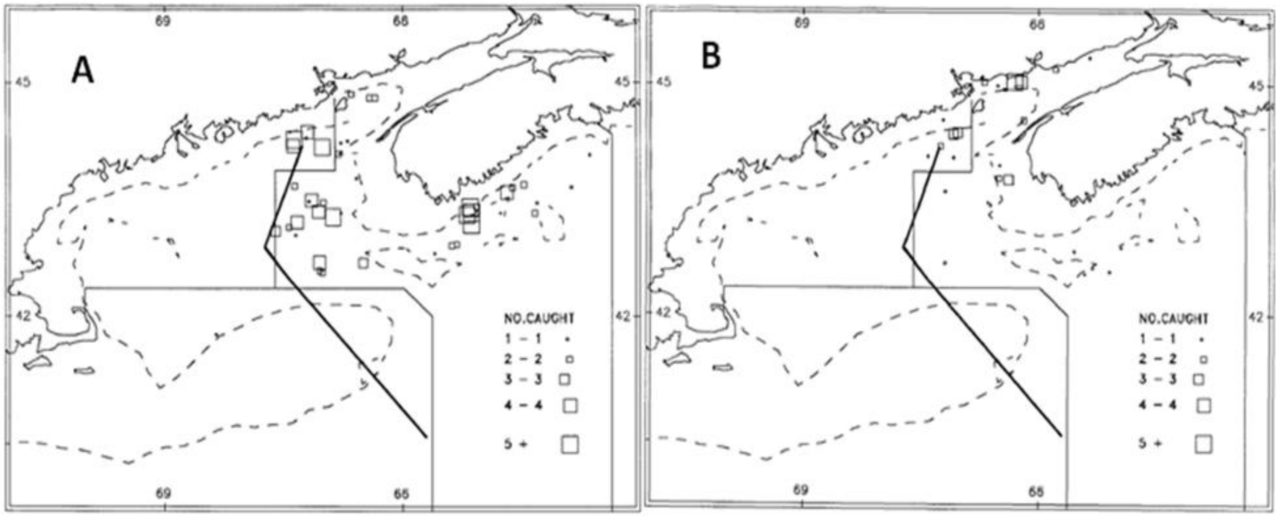

Figure 6: Distribution of spawning witch flounder observed during Canadian Department of Fisheries and Oceans spring (Figure A) and summer (Figure B) trawl surveys on the western Scotian Shelf (Area 4X). Figure taken from Neilson and Hurley (1986).

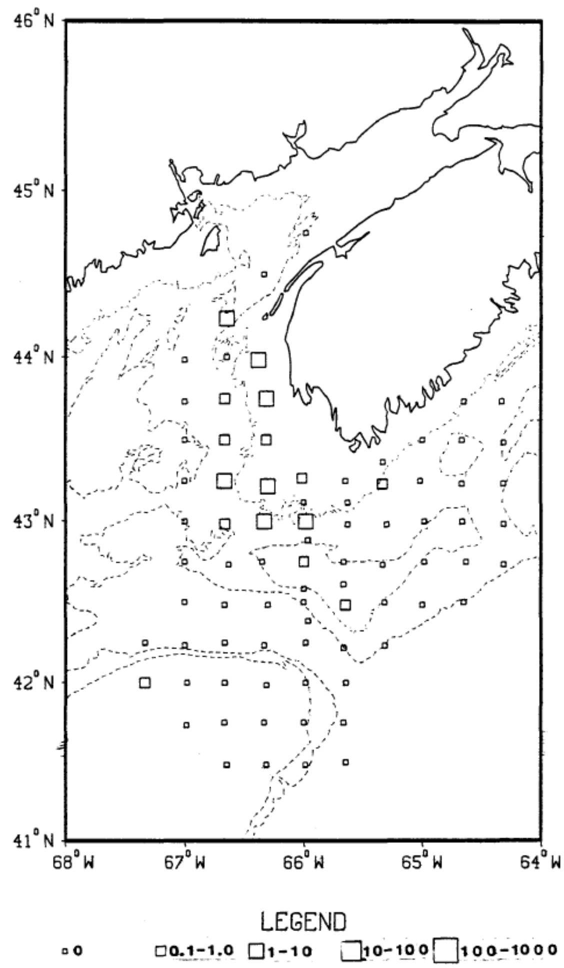

Figure 7. – Distribution of witch flounder eggs on the western Scotian observed during a Marine Fisheries Division ichthyoplankton survey that was conducted in June 1983. Figure taken from Neilson and Hurley (1986).

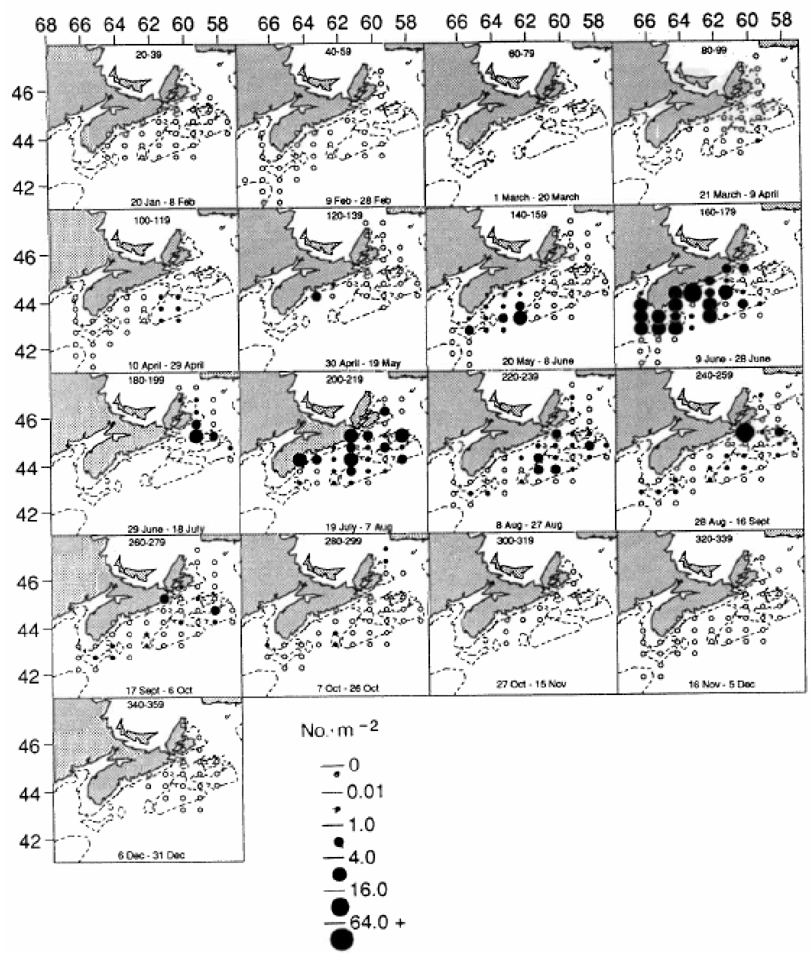

Figure 8. Distribution and abundance of witch flounder eggs observed on the Scotian Shelf during research cruises of the Scotian Shelf Ichthyoplankton Survey. Figure taken from Brander and Hurley (1992).